Booster Fast Loss Monitoring

PIP Booster Workshop

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11/23/15

Fast Loss Monitor Module

Fast Loss Monitors:

- sensitive to losses in single RF bucket (time resolved)

2nd Generation Module Design:

- 2 PMTs and bases
  - Hamamatsu H1949
  - typical gain 2.0e7
- each PMT views 1 scintillator each ~12mm thick
- active area: 50.8mm x 152.4mm
- counters plateaued (V_{thr} = 30mV) to be efficient for MIPs through 1 scint. plate
- assembly surrounded by 5mm thick FR-4 (G-10)

Advantages:

- can be sensitive to single minimum ionizing particle (MIP)
- robust assembly (can be handled by gorilla)
- less sensitive to activation products
- very low noise rates (when PMTs in coincidence)

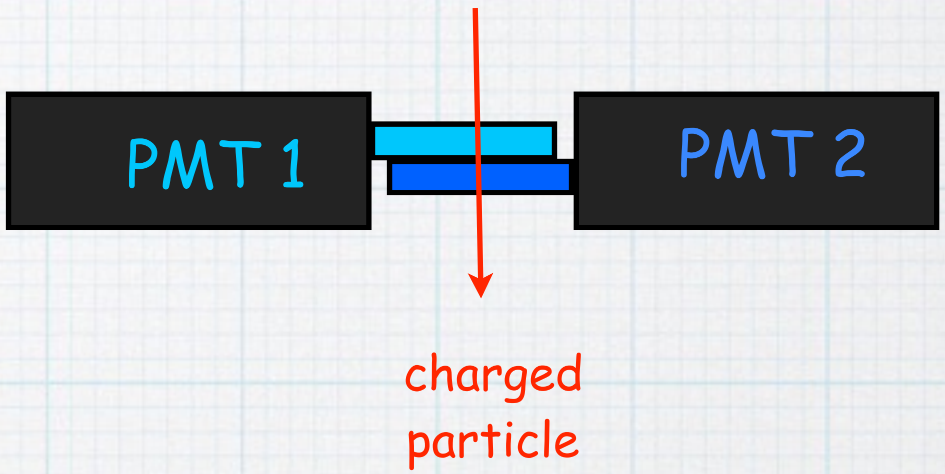
➡ probe of loss dynamics is a by-product of fast detection

Disadvantages:

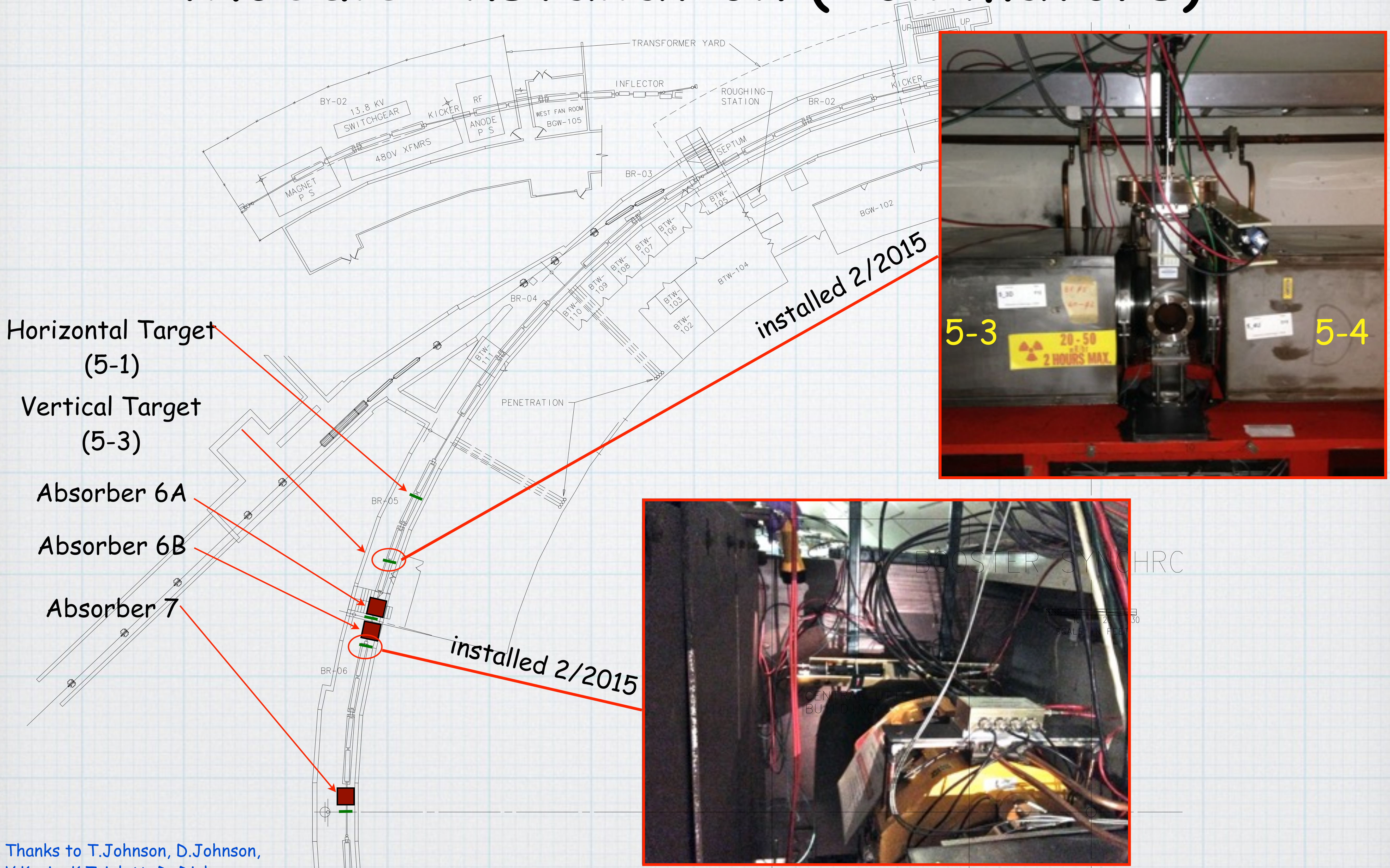
- scintillator damaged by radiation (annual replacement?)

Construction/Calibration details in beams-docDB 4993

Module Schematic

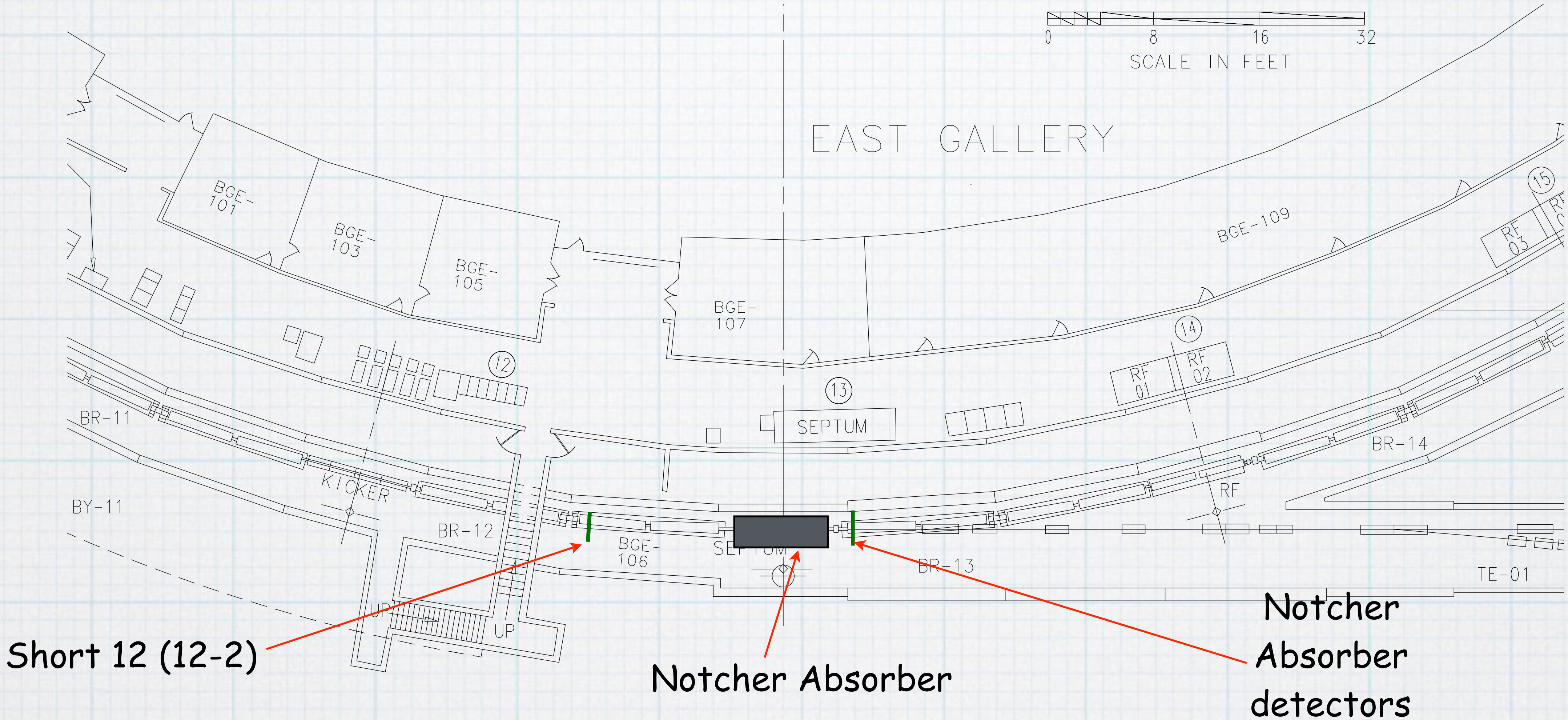


Module Installation (Collimators)

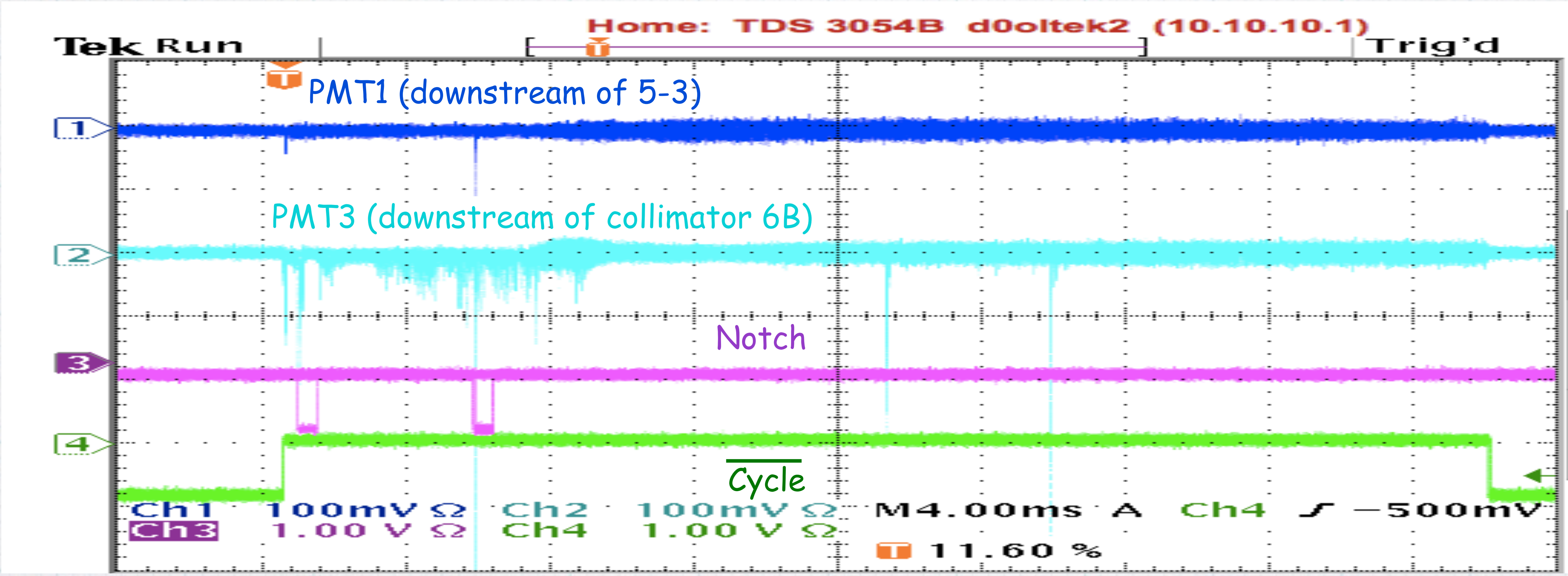


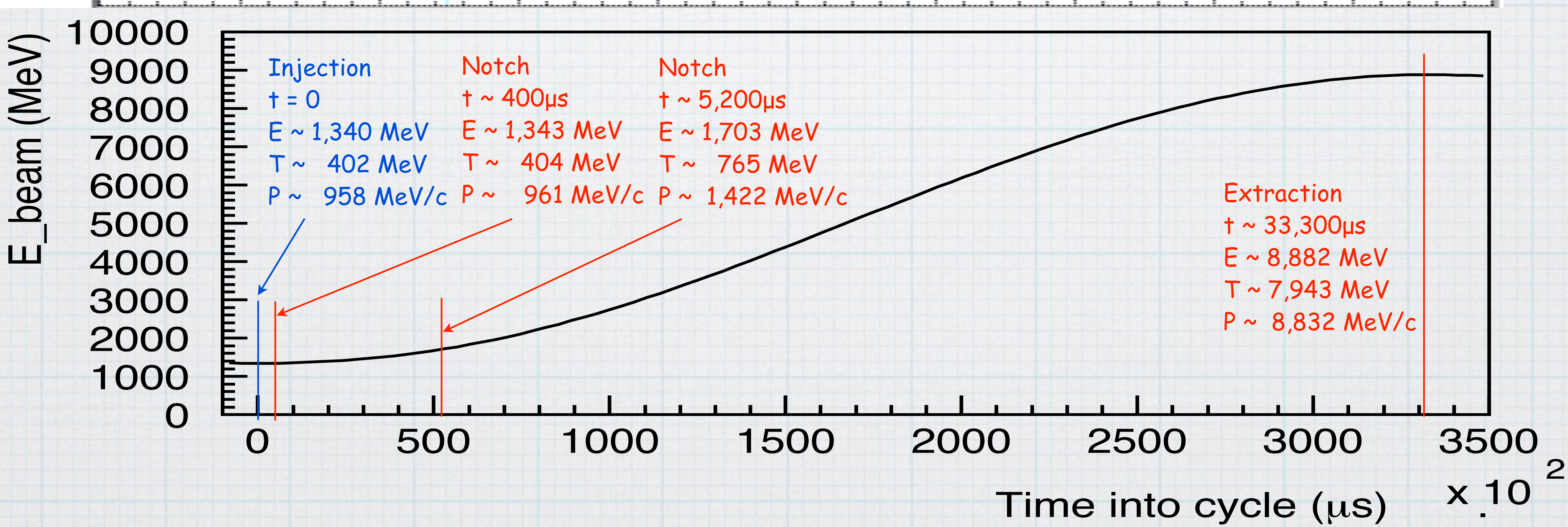
Thanks to T.Johnson, D.Johnson, V.Kapin, K.Triplett, D. Dick

Booster Notching Region



Booster Cycle Overview (3/11/15)





Features in Booster Cycles (3/11/15)

5,266μs into cycle
(Notch @ 5.2ms)

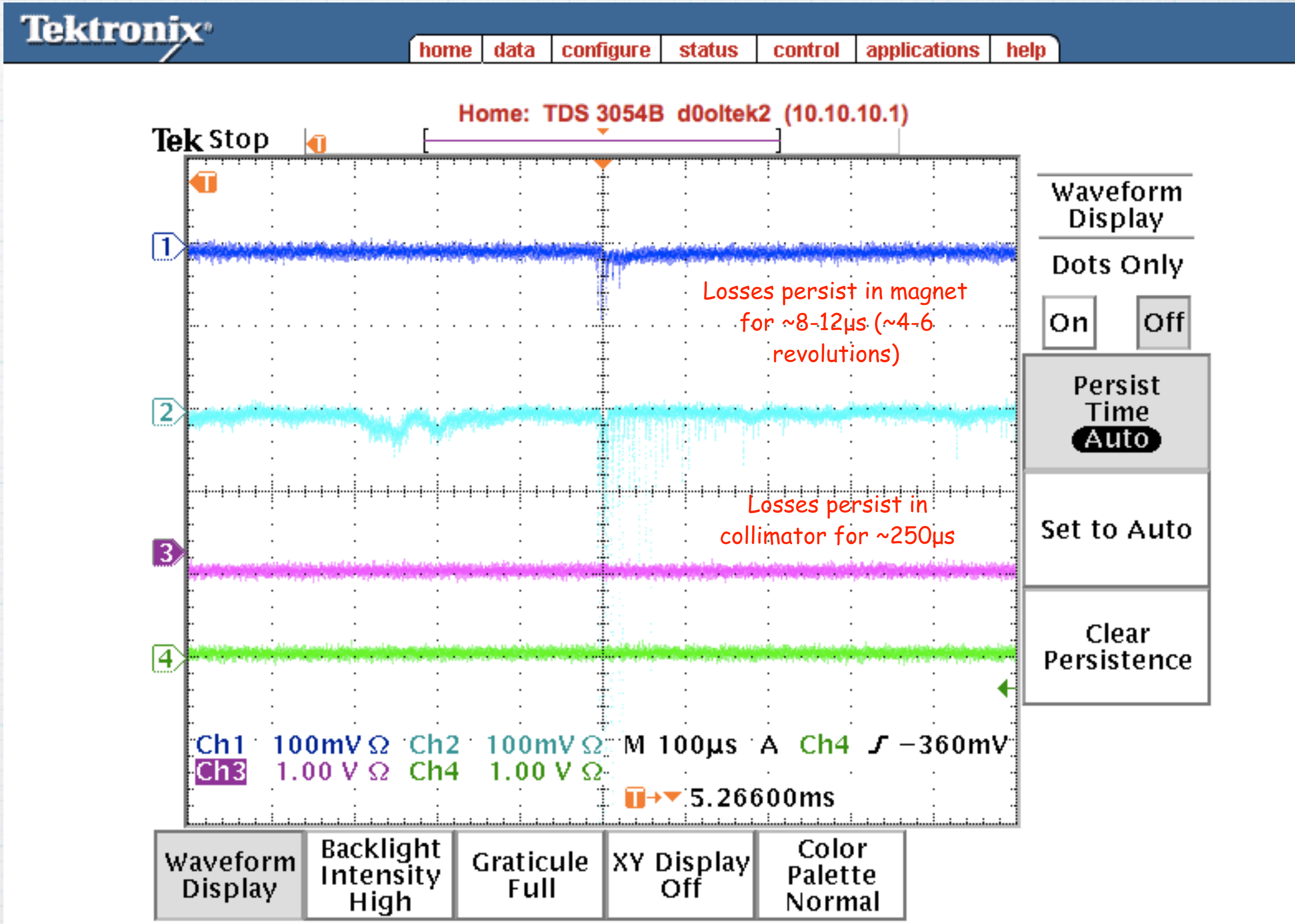
PMT1
downstream of 5-3

PMT3
Collimator 6B

Notch

Cycle

NB: clipline added on 3/18/15



Features in Booster Cycles (3/12/15)

400μs into cycle
(Notch @ 400μs)

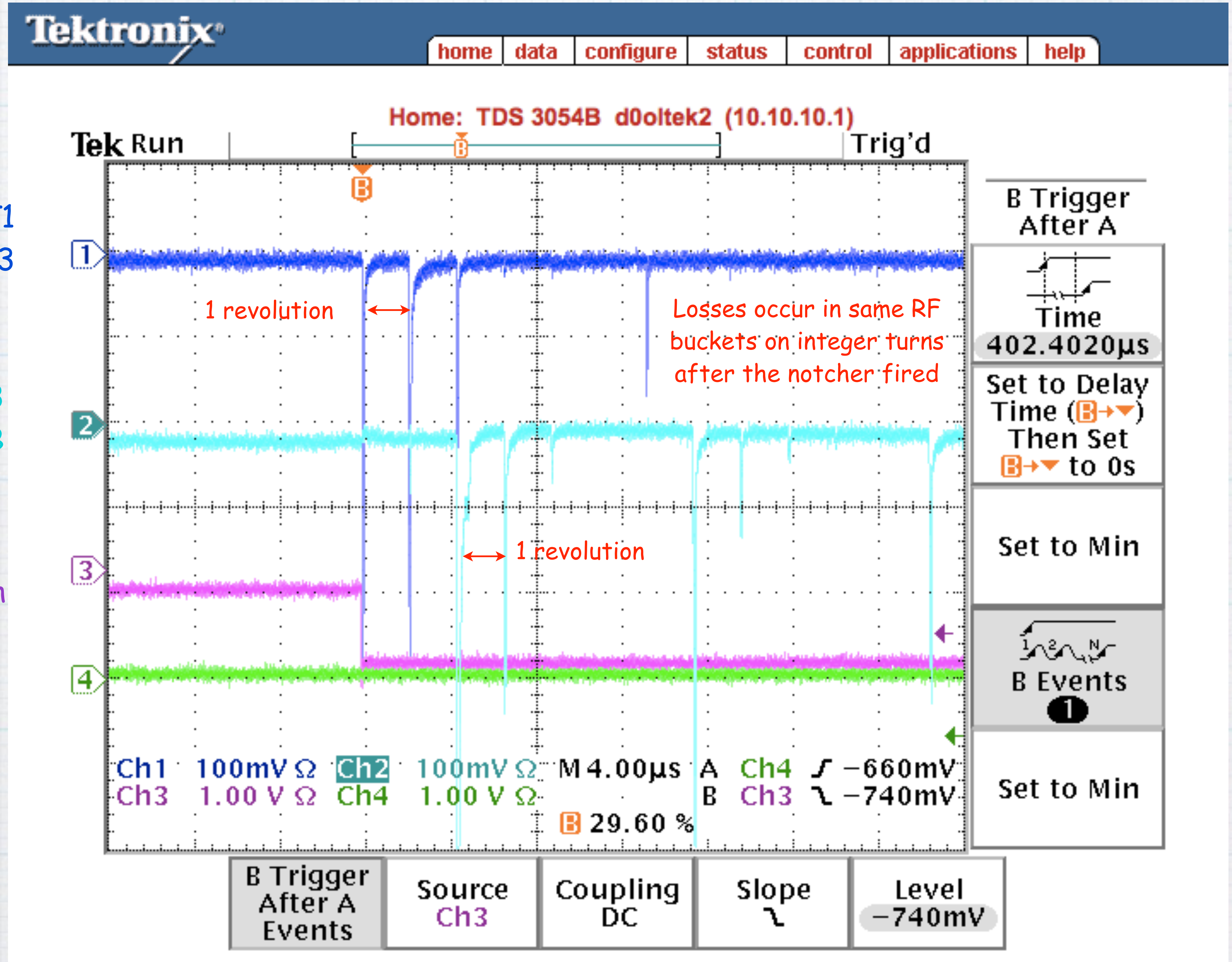
PMT1
downstream of 5-3

PMT3
Collimator 6B

All losses after notch formation similar in character (not always in detail)

Notch

Cycle



NB: clipline added on 3/18/15

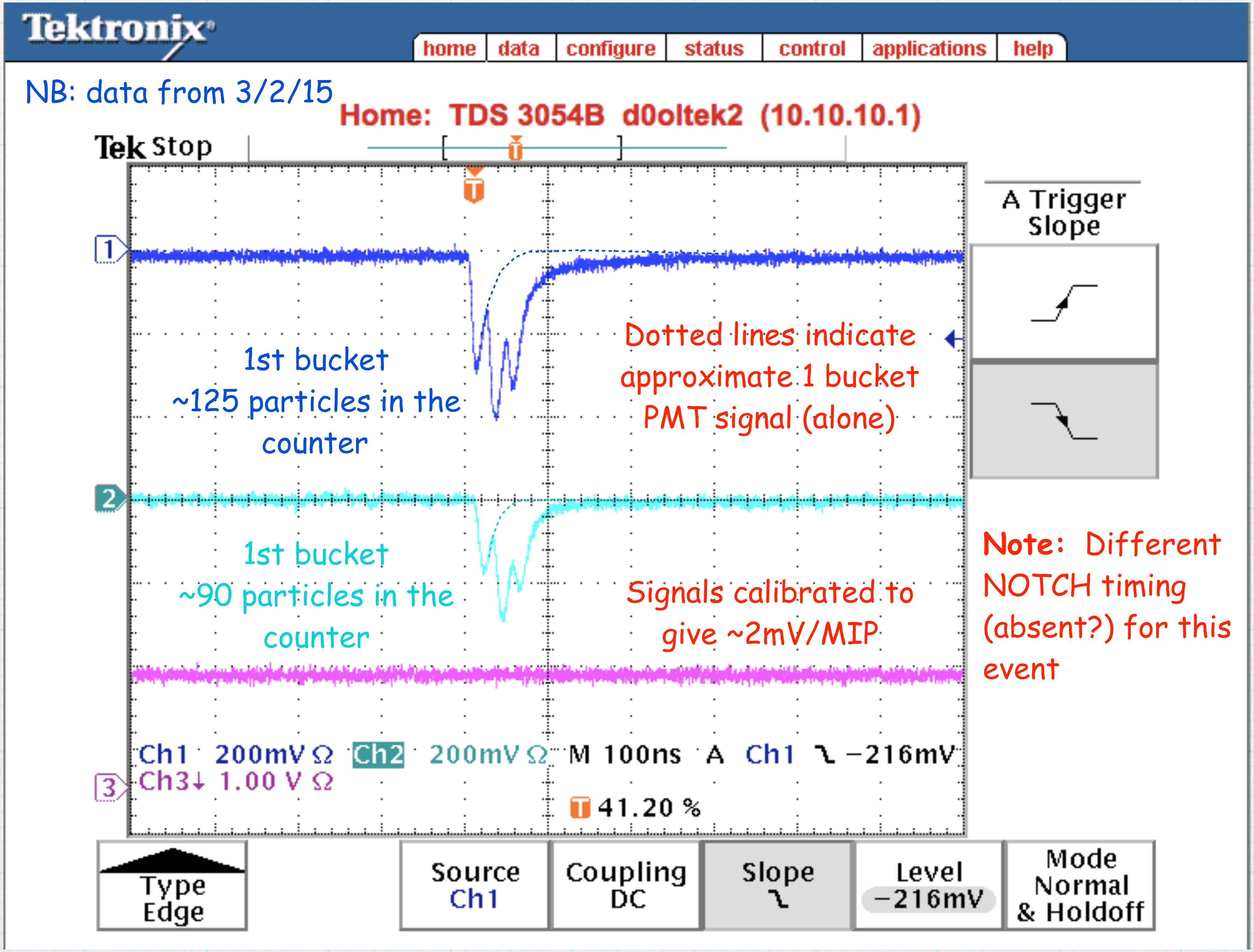
Scale of Fast Losses

PMT1
downstream of 5-3

PMT3
Collimator 6B

Notch

NB: clipline added on 3/18/15



PMT Signals 3/31/15 "Loss Event"

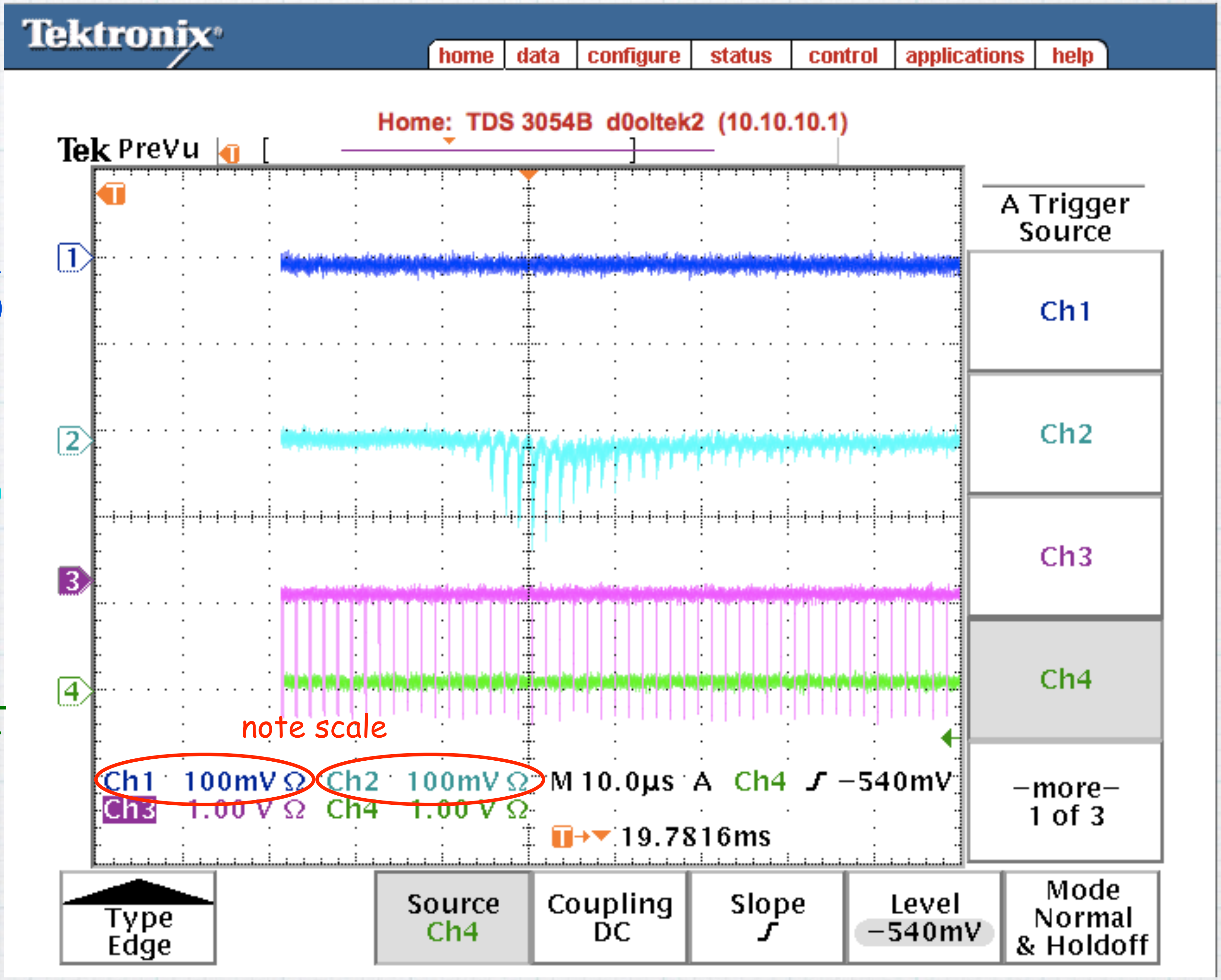
Loss "event"

PMT1
(downstream of 5-3)

PMT3
(collimator 6B)

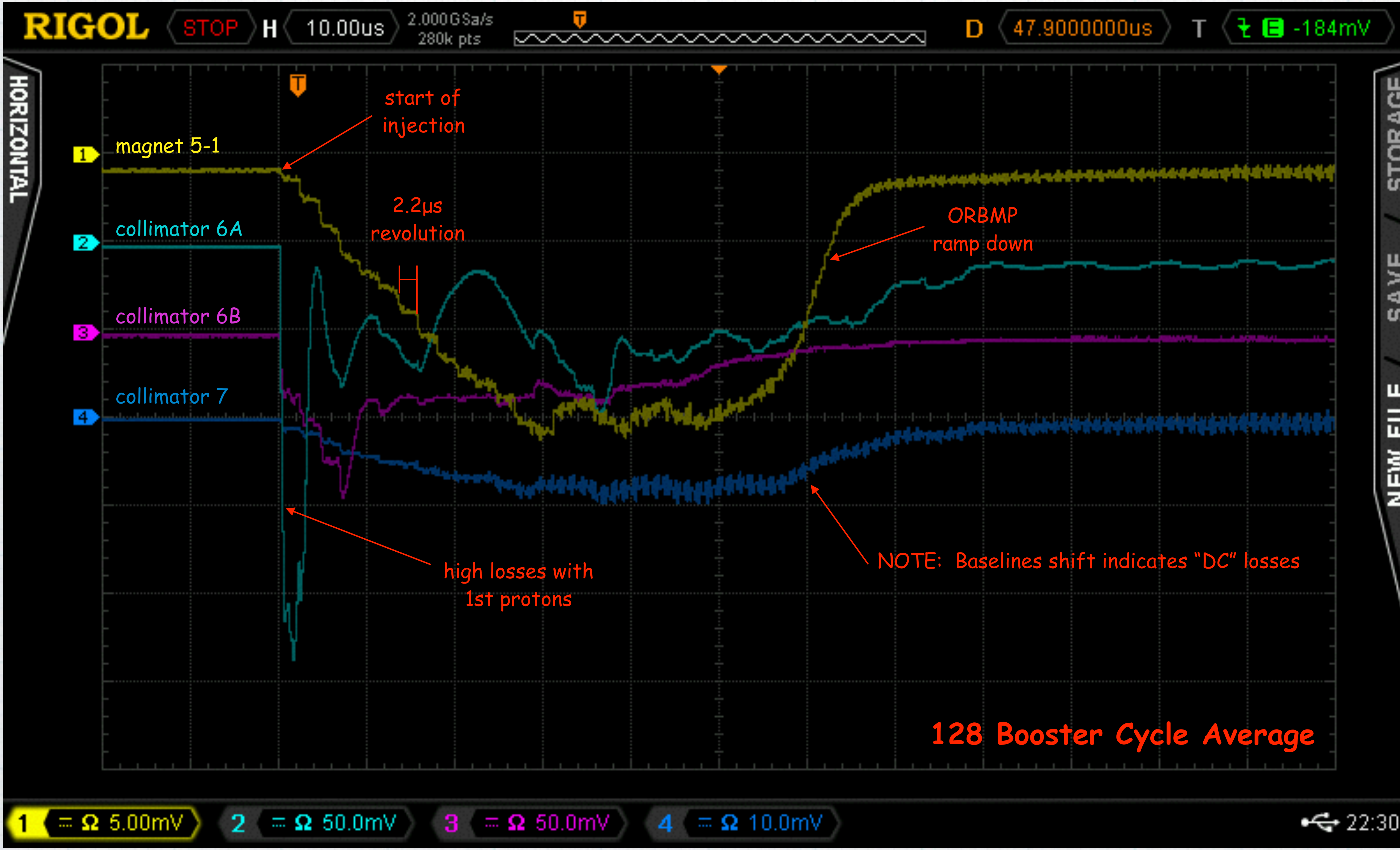
Rev
(RF/84 sync'd at notch)

cycle



Booster Cycle Fast Losses 11/13/15

Injection Fast Losses 11/13/15



Module Readout and Gating

Need quantitative information for tuning and studies

- MADC analog system too slow
- Use AD 333 100MHz scalers and discriminate PMT signals

Instrumentation measures rates/booster cycle (independent of beam):

$$R(i) = \frac{s(i) - s(i-1)}{INJ(i) - INJ(i-1)} \cdot \frac{f_{CLK}}{CLK(i) - CLK(i-1)}$$

clock: 38.768 kHz TTL
temp compensated oscillator

- Rates average signals over period between $12 events (~1.33s), normalized per booster cycle
- Use 333 scaler module for readout
- Rates normalized by number of booster cycles
- **Clock:** a periodic signal with a well known (stable) frequency. Because the booster RF is modulated it can't be a clock signal.
- **Booster RF:** Booster RF signal (logic level) to provide background rejection from non-prompt particles. Also counts "hits" for time-over-threshold discriminator.
- **Injection:** Signal that beam may be injected into the booster (beam may not be present)
- **Gates:** Time intervals of interest to measure rates in counter modules. To be fully defined, we need a starting time (in the booster cycle) and a duration.

➡For instrumentation to be effective, we want to sample periods that are constant (**VERY** similar) for every booster cycle.

Fast Loss Rates in ACNET

Gates before summer shutdown (instruments at 5-3 and 6B)

Gate	tmin	tmax	Comment
1	Inj	Inj + 300μs	injection losses*
2	Inj + 300μs	Inj + 800μs	losses around 400μs structure*
3	Notch	Notch + 500μs	losses around notch formation
4	Notch + 500μs	Notch + 2800μs	losses around notch formation (separated for timing)
5	Notch + 2800	BES	losses in rest of booster cycle#

Gates after summer shutdown (instruments at 5-1, 5-3, 6A, 6B, 7)

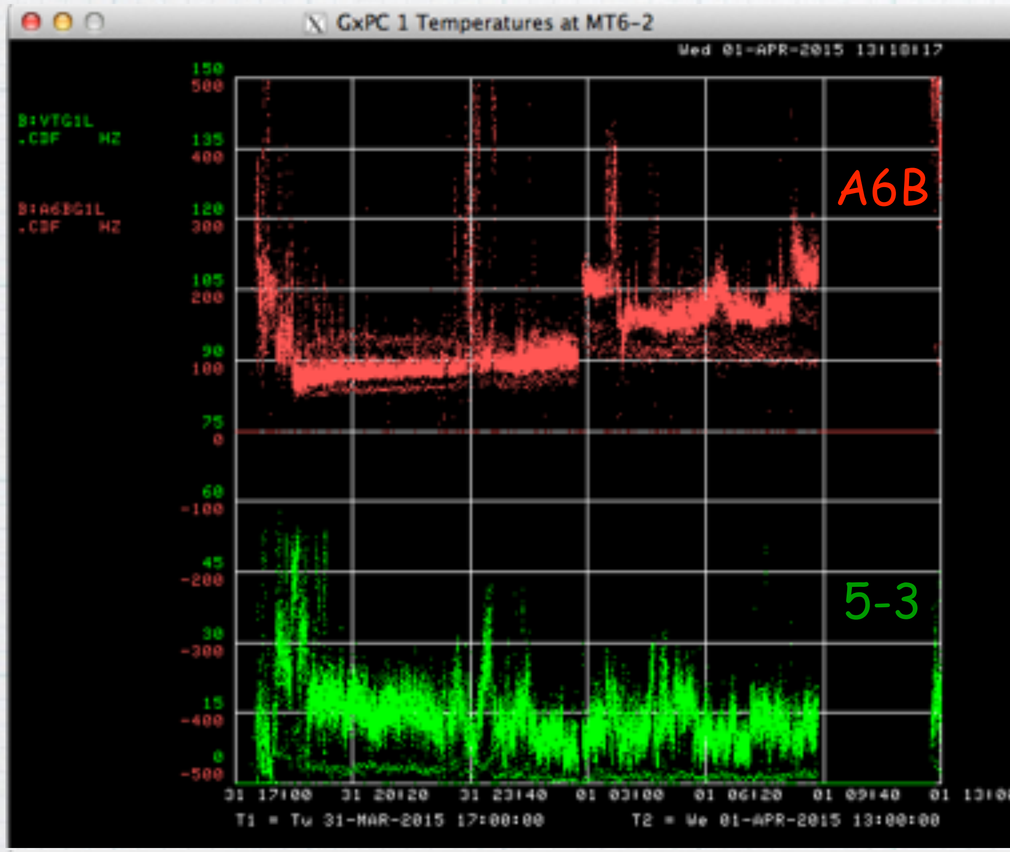
Need discussion:

- Current booster cycle has losses from different activities in cycle overlapping.
- Limited number of gates/333 modules

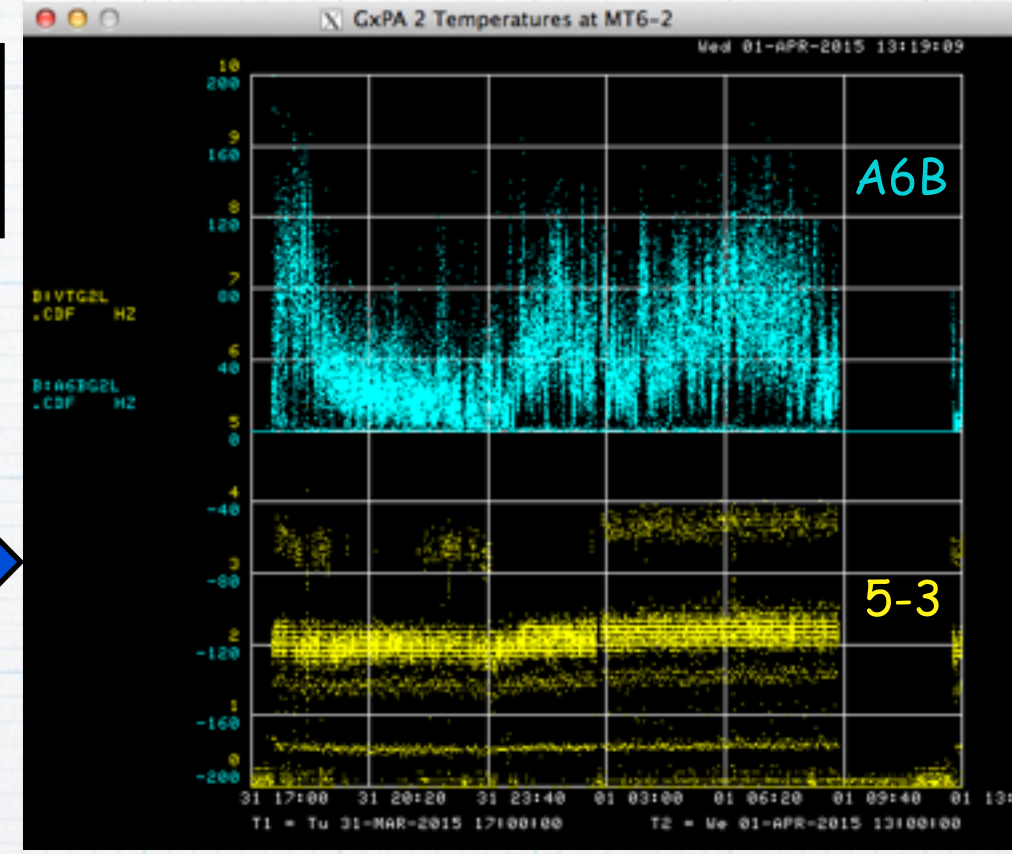
Candidates:

- Injection
- RF capture
- Notching
- Transition crossing
- Extraction

Fast Loss Rates in ACNET

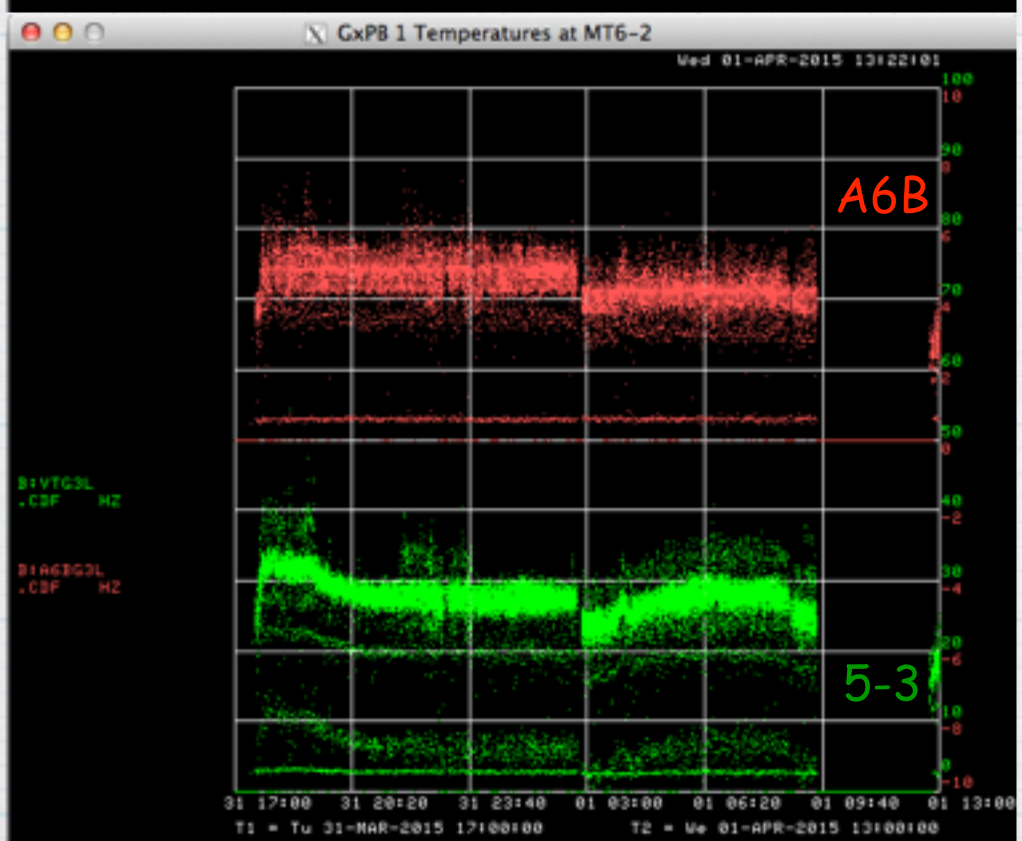


Gate 1
I -> I+300μs



Gate 2
I+300μs -> I+800μs

Notch at 5,200μs



Gate 3
N -> N+500μs

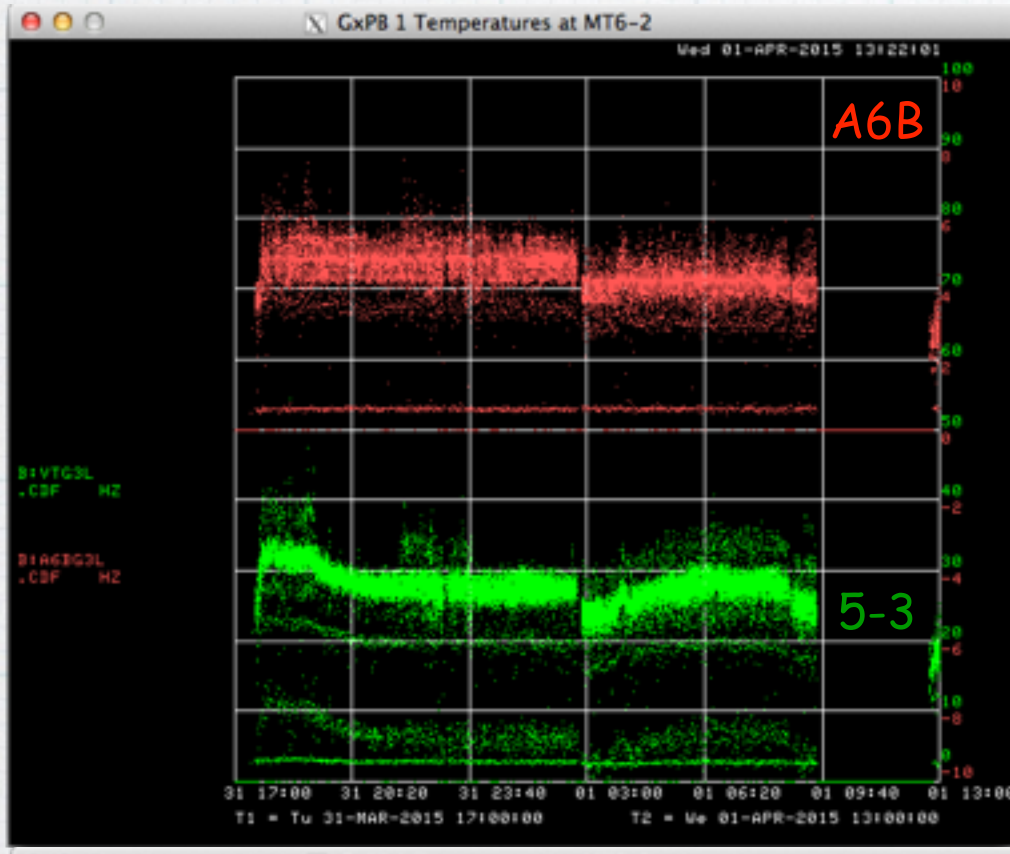
Rate = 0 when no notch present

Data shown for time interval:
3/31 17:00 thru 4/1 13:00

Note:

Correlation between some features observed at injection and features around notch formation for these data.

Fast Loss Rates in ACNET

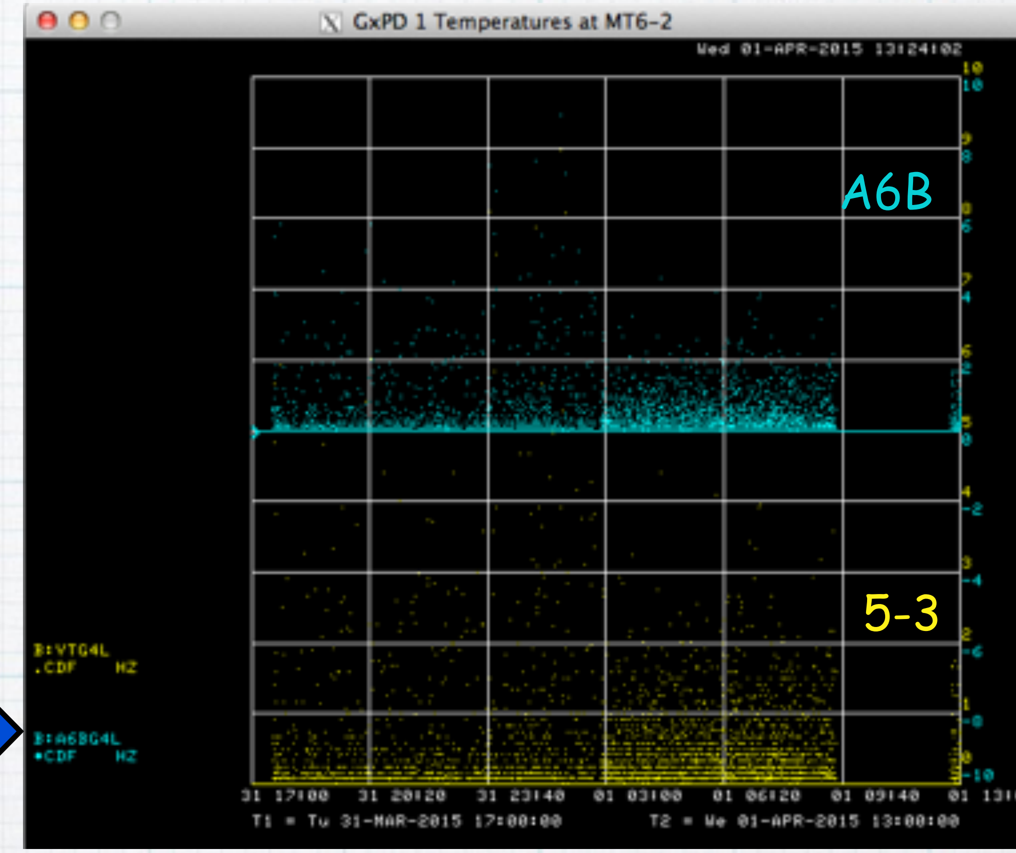


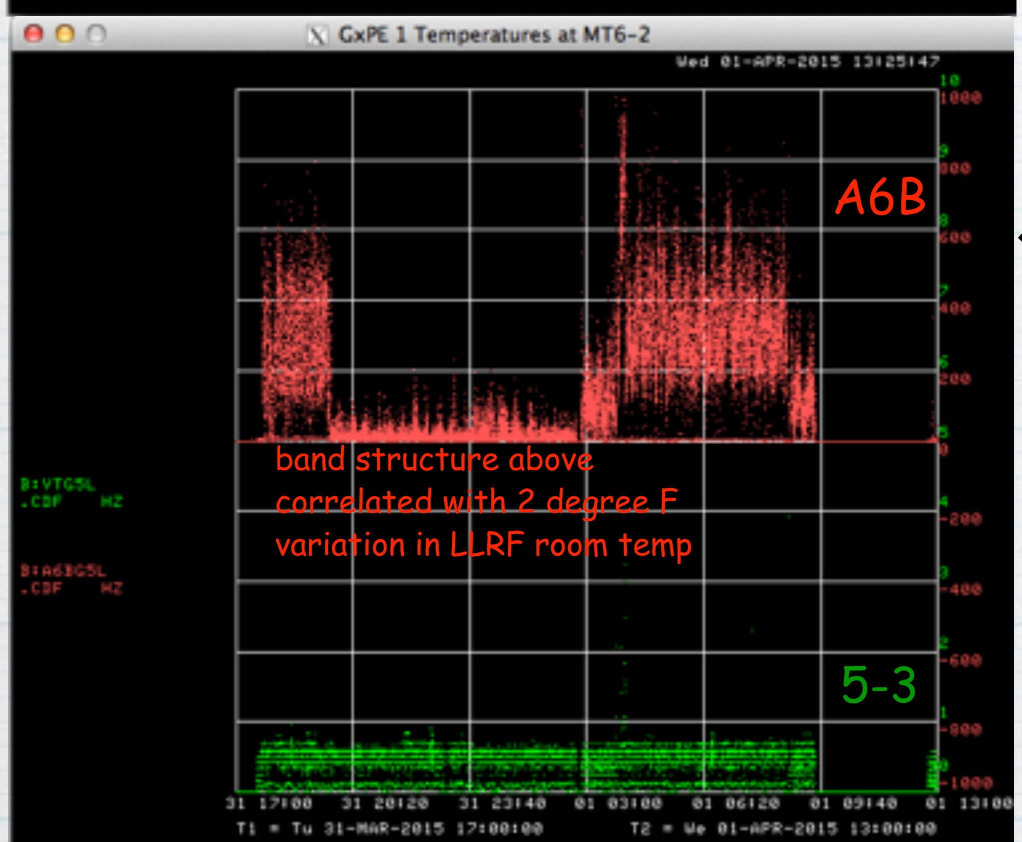
Gate 3
N -> N+500μs

Notch at 5,200μs

Rate = 0 when no notch present

Gate 4
N+500 -> N+2,800μs





Gate 5
N+2,800μs -> BES

Data shown for time interval:
3/31 17:00 thru 4/1 13:00

Note:

Correlation between some features observed at injection and features around notch formation and late in the cycle for these data.

Plans & Summary

Plans (next few weeks)

- Complete installation/commissioning of systems
  - notcher system (ready for 'scope-permanent installation)
  - collimator system
- determine gates for readout (collimator system)
- cable readout for collimator system (expanded system over summer shutdown)

➡expect system fully operational early Dec.

Long term plans

- autopsy counters exposed in booster for period 2/15 - 7/15 (radiation damage)
- begin making detector replacements
- explore rad-hard alternative to scintillator/PMT detectors (underway)

New very fast loss instruments installed

- single RF bucket resolution on losses
- interesting data from 'scope traces
- rate measurements tested - yield interesting results
- commissioning underway for collimator system

Need catchy name for system

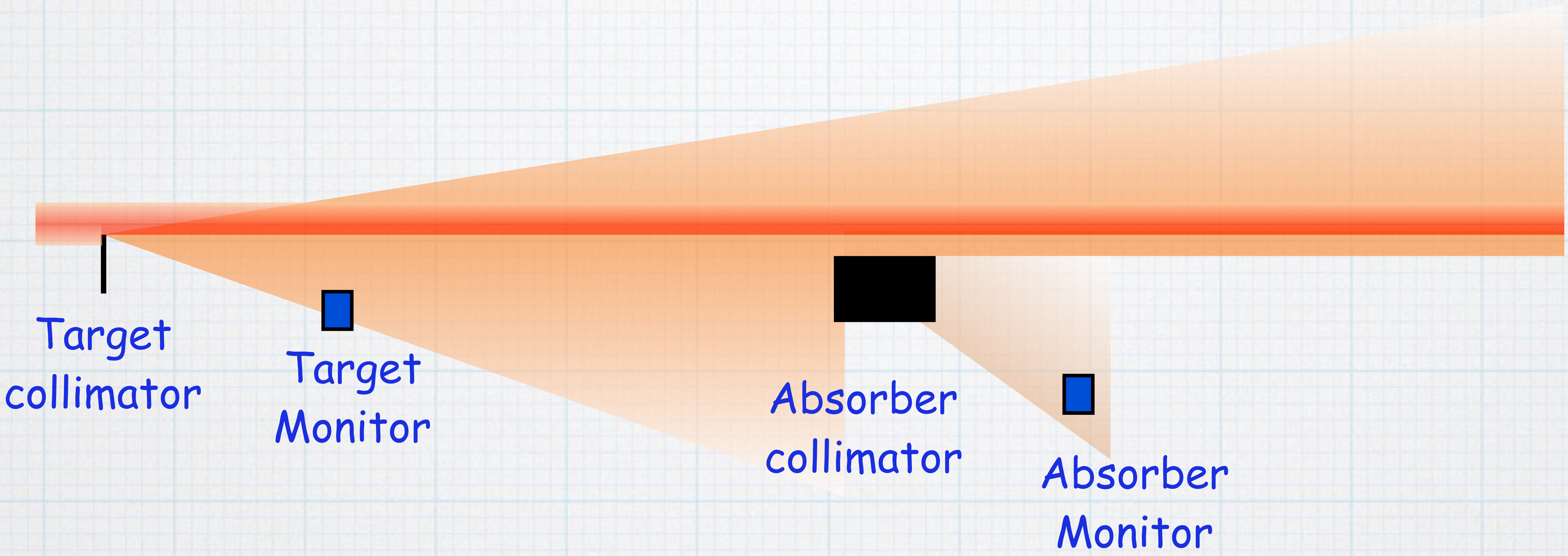
Acknowledgements

The following folks contributed time/resources (tools) an information used in this talk

- C.Bhat
- S.Chaurize
- R.Crouch
- C.Drennen
- D.Dick
- V.Kapin
- E.Hahn
- D.Johnson
- T.Johnson
- C.Ornelas
- W.Pellico
- T.Sullivan
- M.Syphers
- K.Triplett

Back Up Slides

Two Stage Collimation



My Understanding:

- Target disrupts beam halo
- Absorber absorbs disrupted beam
- Target/Absorber monitors "observe" target and absorber collimators

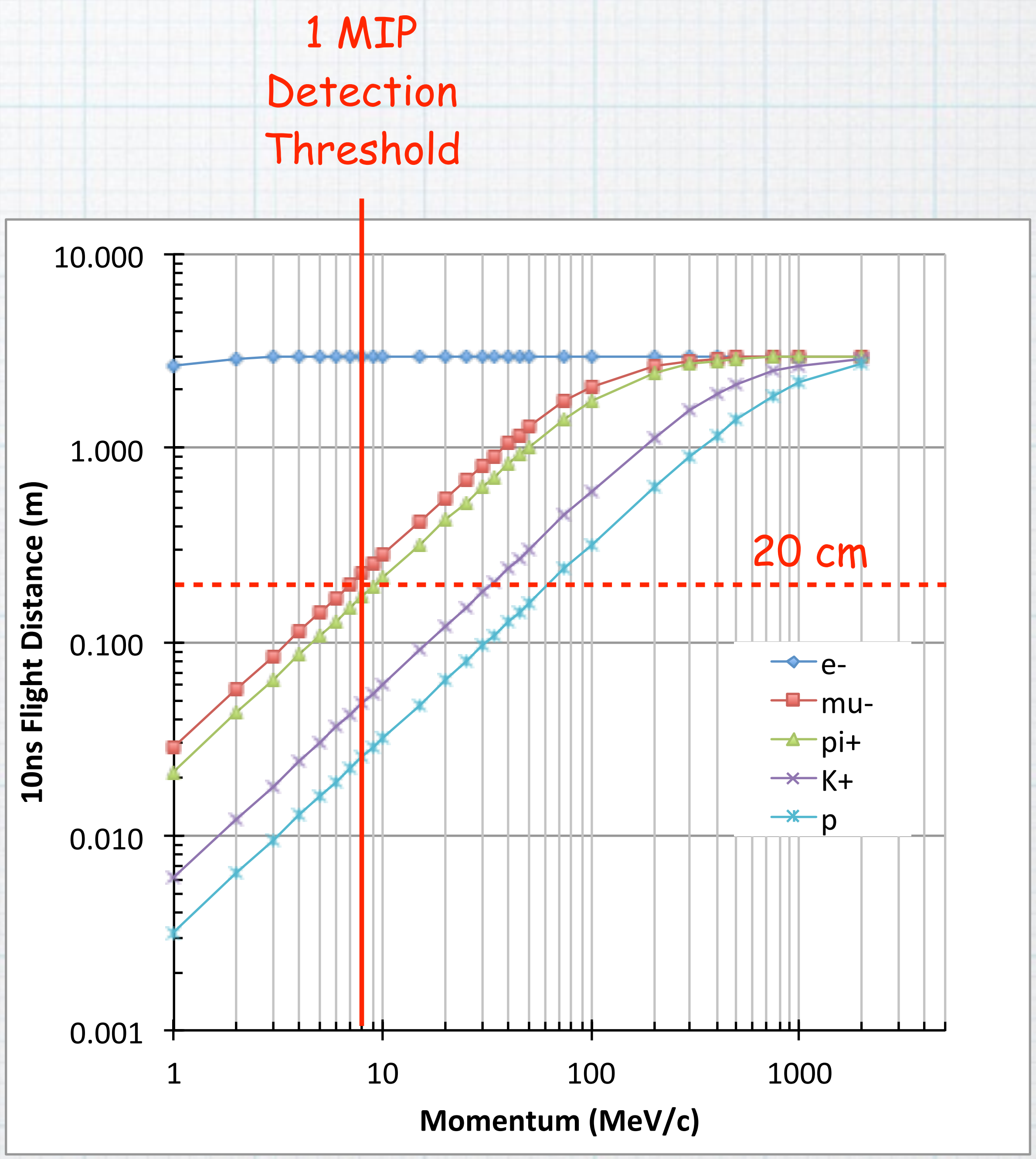
➡Absorber should "shadow" target (absorber farther from beam core)

Module Placement

Considerations:

- Observe particles from single RF bucket
- Low detection threshold (single MIP)
- Wide variation in beam kinetic energy (400 - 8000 MeV).

➡Place detectors < 20cm from loss source



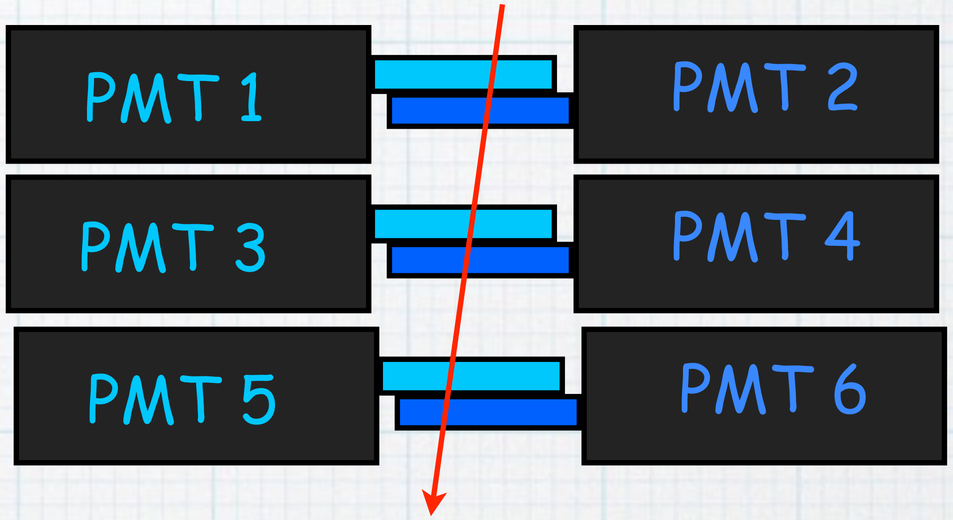
Module Calibration

Understand individual detector response

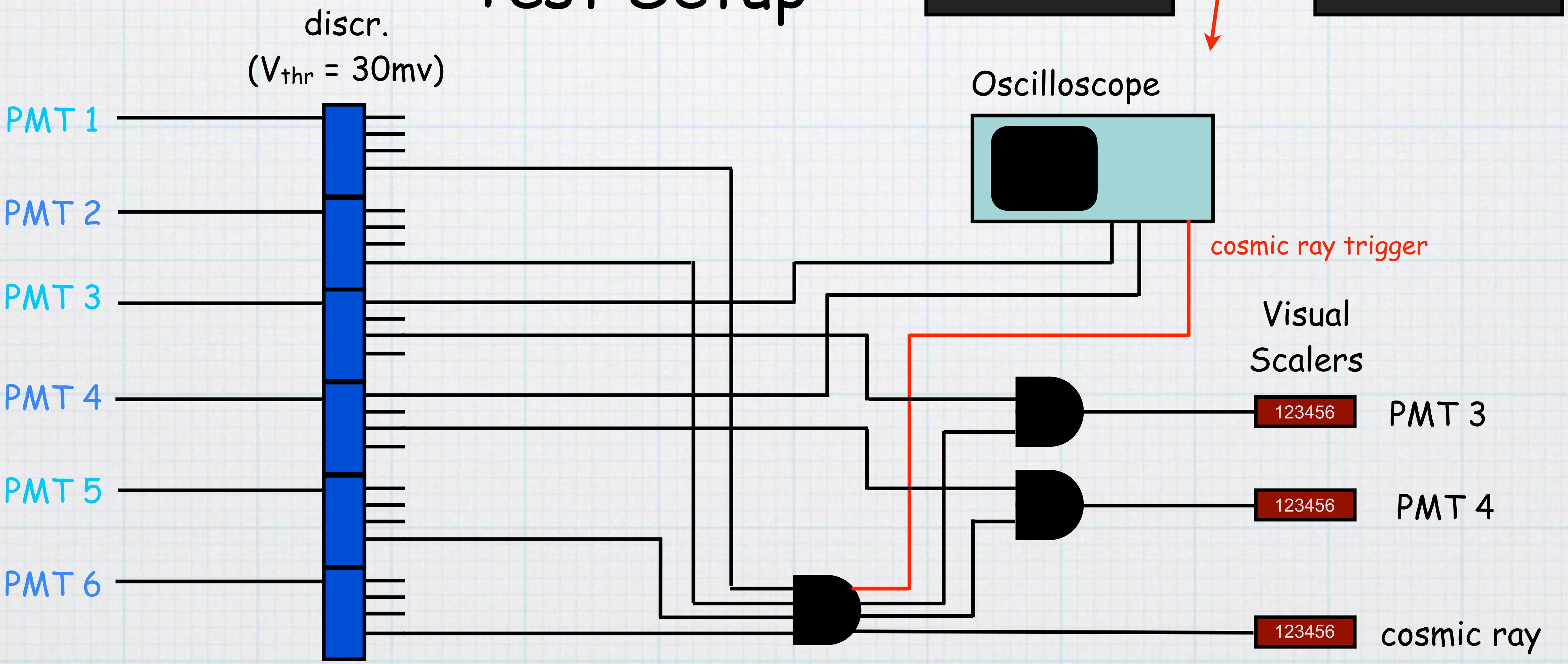
- PMT signal
- Efficiency vs HV (given V_{thr})
- Pulse height vs HV
- Dark rate (noise) vs HV

Physical Setup

cosmic ray



Test Setup

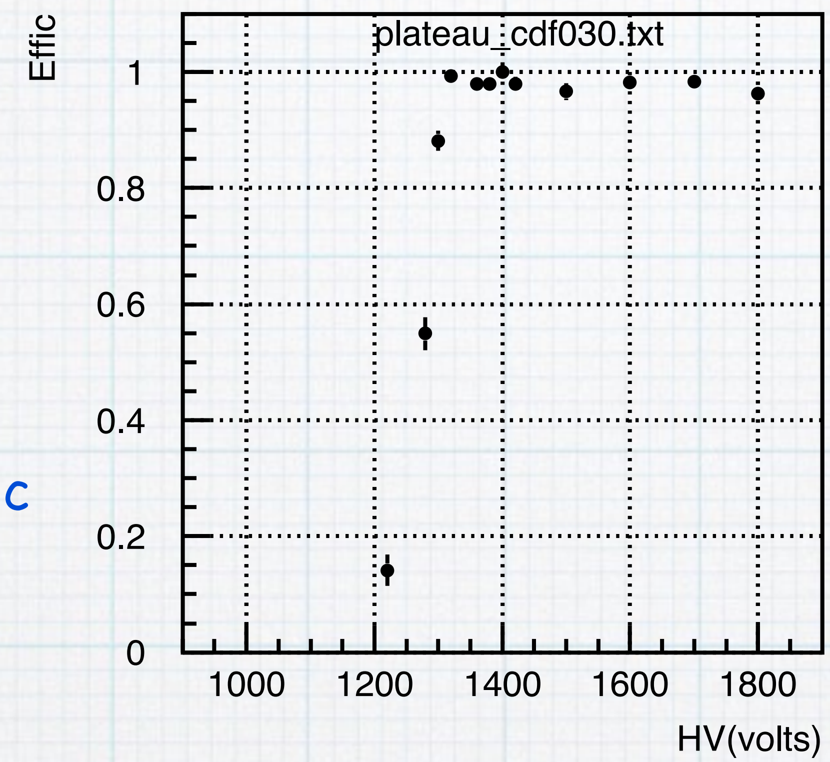


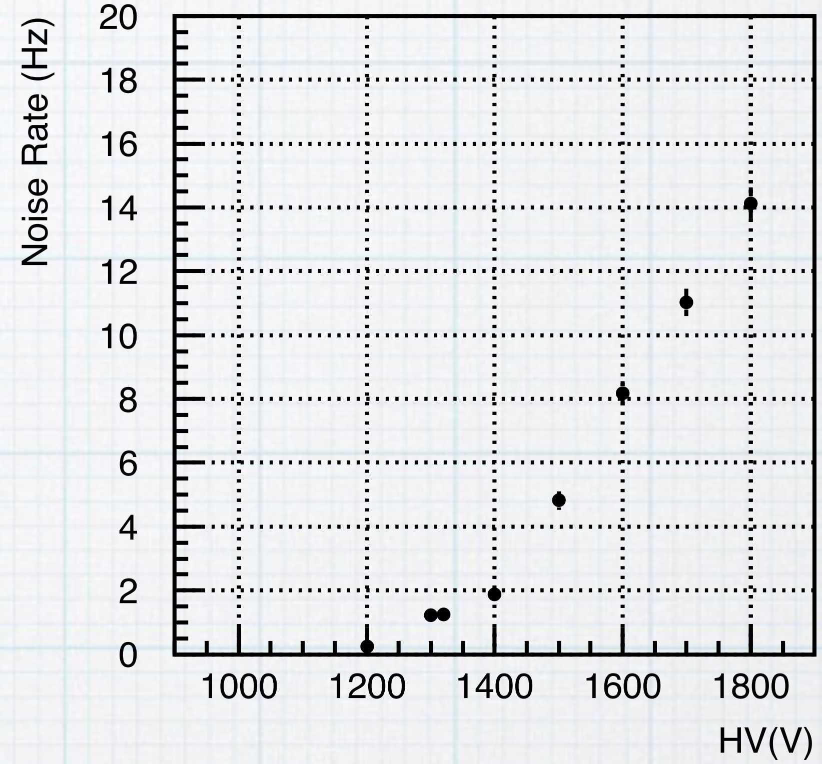
Typical Calibration (CDF030)

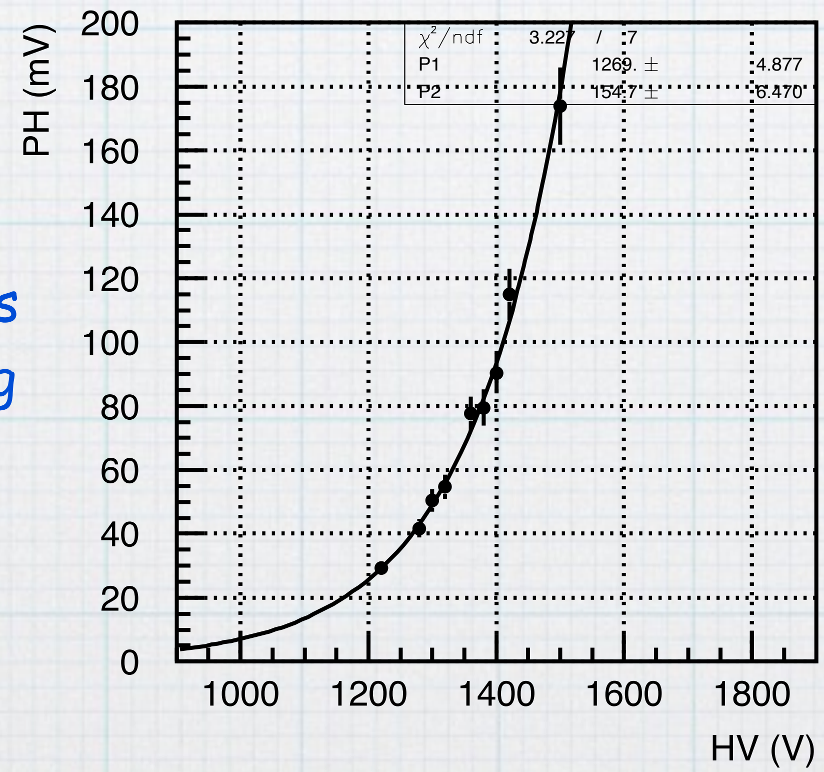
Notes:

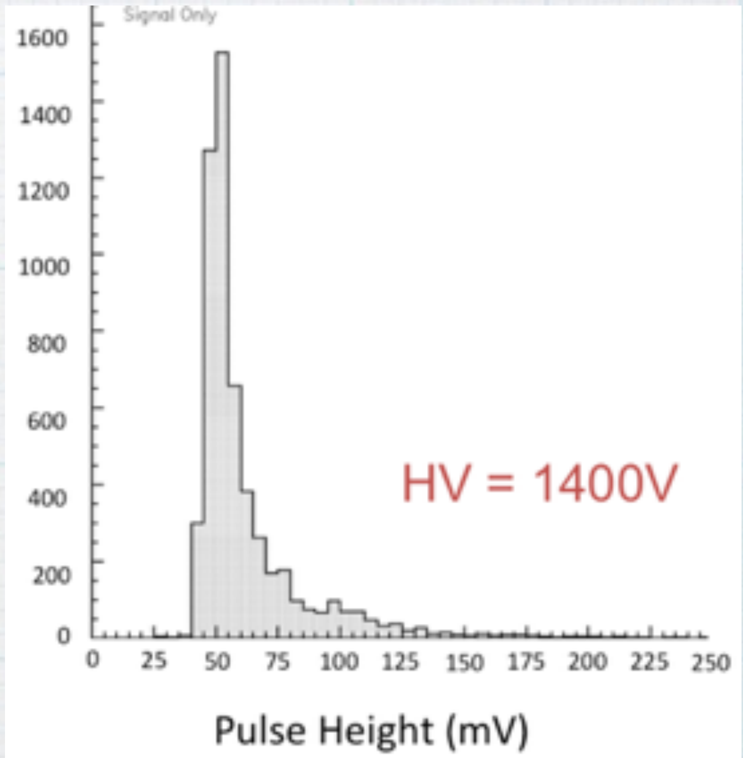
- Only relative efficiency is measured and includes a component due to geometric acceptance of cosmic rays and may differ from setup to setup.
- Noise rates measured by counting for 1 minute and dividing by 60.
- Pulse height determined by peak-to-peak measurements w/ an oscilloscope averaging over 512 4-fold coincidences.

Ref: C.Ornelas, beams-doc-4993

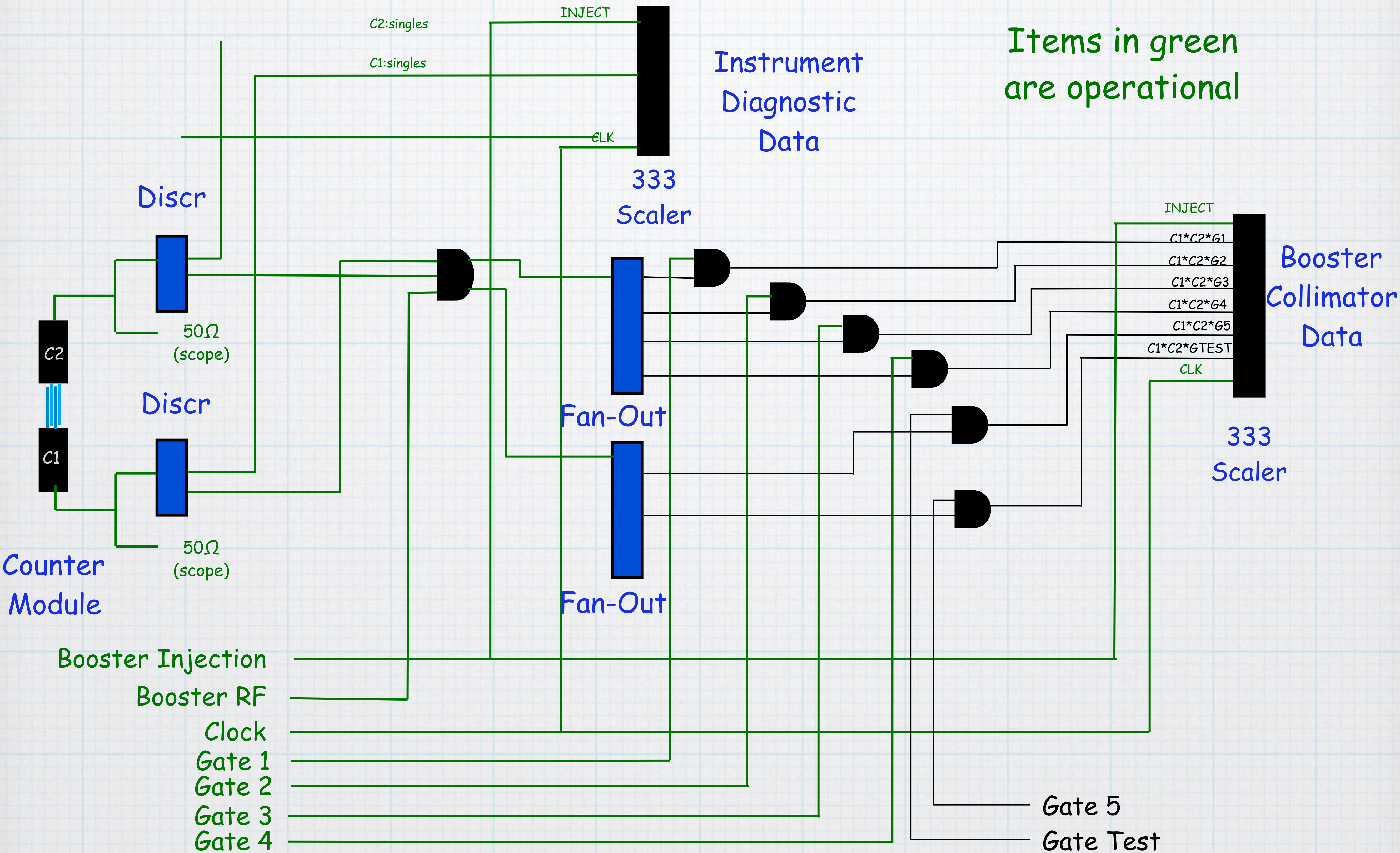




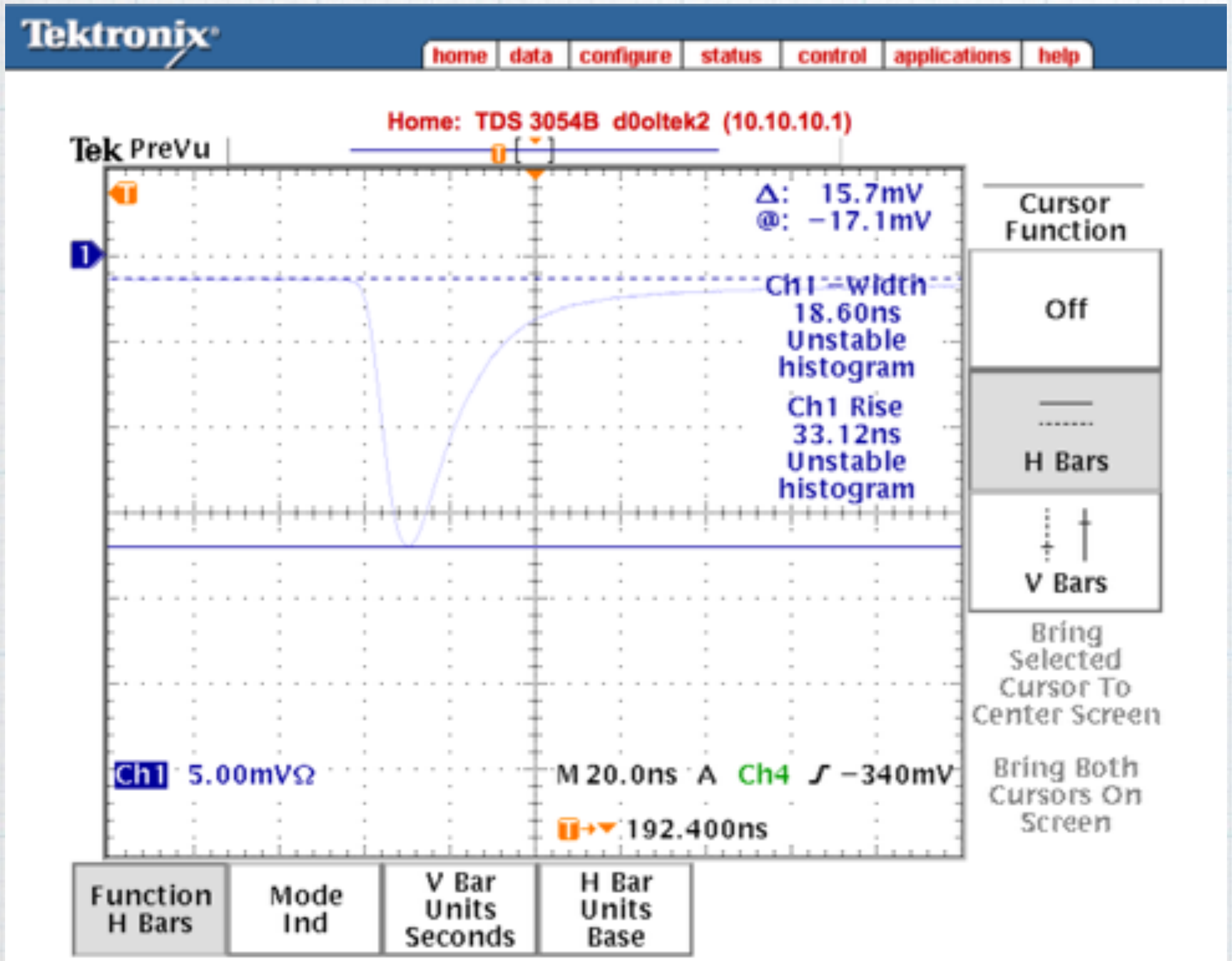


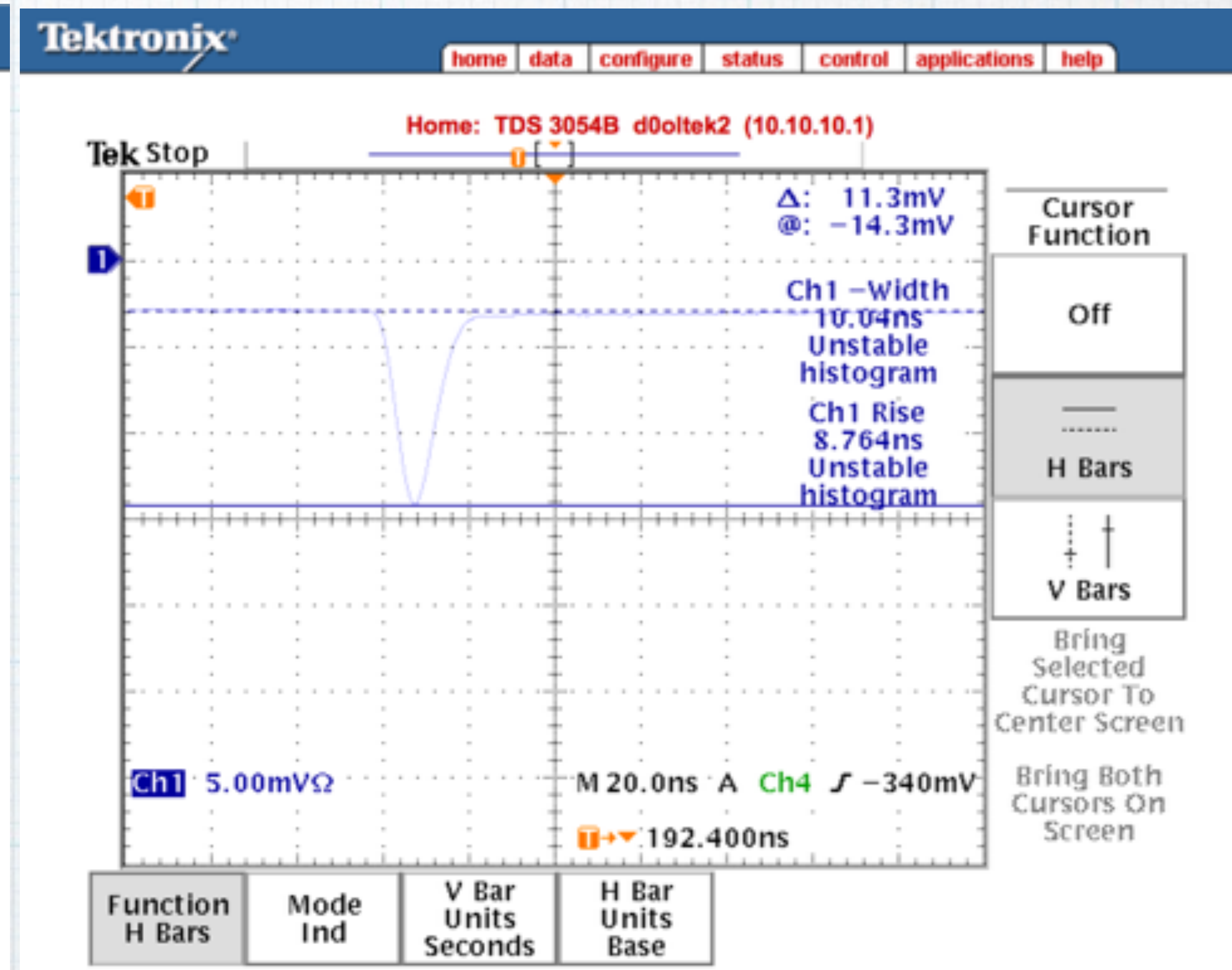


Readout Logic (Details/Module)



Clip Line Pulse Narrowing

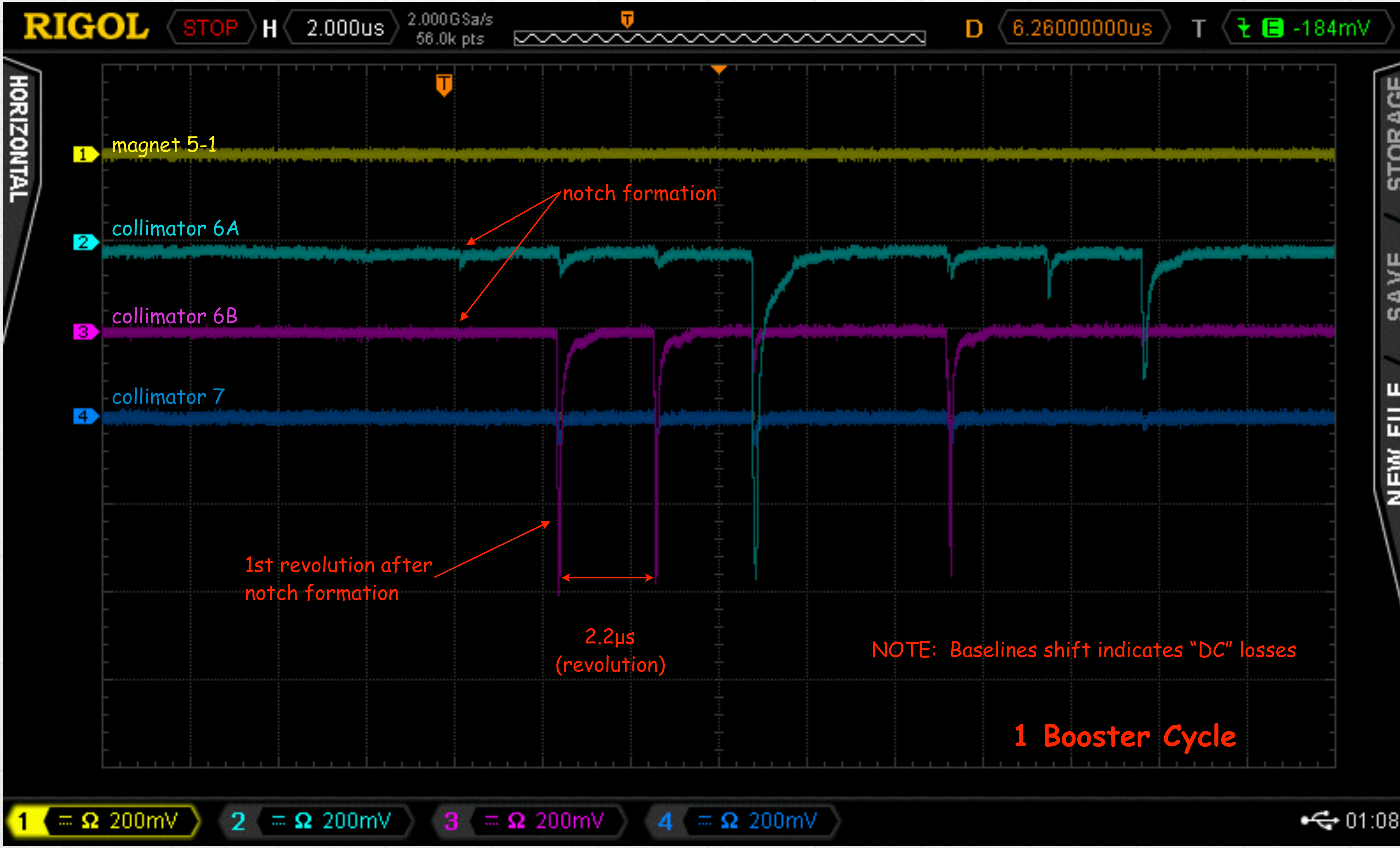




Cable Length = 235ns
Clipline R = 50Ω
#samples = 512

Cable Length = 235ns
Clipline R = 10Ω
#samples = 512

Injection Fast Losses 11/13/15



Notch Formation Fast Losses 11/13/15